Technical Document 2035
December 1990

Navy Compliance With Volatile Organic Compounds (VOC) Regulations for Marine Coatings

T. Thielen

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152-5000

J. D. FONTANA, CAPT, USN
Commander

H. R. TALKINGTON, Acting
Technical Director

ADMINISTRATIVE INFORMATION

The study covered in this document was conducted during October 1990 and November 1990. It was funded with in-house funds. The work was performed by Code 0065 of the Naval Ocean Systems Center (NOSC), San Diego, California.

Released by
D. L. Lydy, Head
Engineering Branch

Under authority of
L. P. Guy III, Head
Facilities Engineering
Office

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1.0 INTRODUCTION

GENERAL

Navy ships are complex, engineered structures that require a sophisticated array of coatings for various locations and components, including underwater hulls; main and subdeck floors; interior operational and living quarters; bilge, ballast, and storage tanks; machinery; and equipment. Among the functions required of these coatings are corrosion protection, fouling resistance, skid resistance, fire retardance, visibility, identification, scrubbability, and aesthetics.

Any regulation or ruling that restricts or controls the level of volatile organic compounds (VOC) in ship coatings can significantly affect the Navy's operations. In addition, because construction, repair, and maintenance of Navy ships represent the bulk of the work for private-sector shipyards, the response and reactions of the Navy to proposed regulations will determine the direction of the entire marine-paint industry.

NAVY VOC-ISSUE CONCERNS

Some of the specific Navy concerns arising from the VOC issue are

- Some current paint and coating specifications do not meet California VOC regulations.
- New VOC-complying coatings may be required by shipyards before their field performance can be verified. This requirement increases the likelihood of early failure, higher costs, potentially adverse effects on fleet operations, and increased frequency of VOC emissions during repair and repainting.
- While the Navy is directed to comply with all environmental laws and regulations, there is no assurance of uniform constraints by regions, states, or the local air-pollution control districts (APCDs).
- The Navy is also trying to institute other directives to reduce overall cost and to increase coating lifetimes.

2.0 VOC REGULATIONS FOR MARINE COATINGS

The 1970 Clean-Air Act and its extensions set national ambient air-quality standards (NAAQS) for pollutants such as ozone and carbon monoxide. A large number of the major metropolitan areas have failed to meet the NAAQS level of 0.12 ppm for ozone. Volatile organic compounds resulting from applying marine coatings are considered a source of ozone because they react photochemically with atmospheric gases to form smog. Thus, the coatings industry has been subjected to various regulations limiting the total VOC emissions. Each state is required to submit a state implementation plan (SIP) to describe how it will achieve the required limits.

Coatings for Miscellaneous Metal Parts was one of the earliest categories of coatings to be regulated. This category covers painting in shops and other enclosed stationary facilities. Until very recently, most coatings for surface ships have been classified under regulations for Miscellaneous Metal Parts.

The area of the country most active in regulating VOC emissions for coatings is California; this region consists primarily of the following major air-pollution control districts: the San Francisco Bay area (Bay Area Air-Quality Management District—BAAQMD), the Los Angeles area (South Coast Air-Quality Management District—SCAQMD). and the San Diego APCD. These are also districts with major Navy and private-sector shipyards and marine-coatings facilities.

The new regulations were adopted in November 1988 after months of negotiation by private-sector shipyards, paint companies, and air-quality management districts in California. Major features of the regulations in the two areas are

San Francisco Bay Area, BAAQMD

- Air-dried coatings, 340 grams per liter (g/l)
- Baked coatings, 275 g/l
- No exemption on hull paints and antifouling paints that also are regulated by the Environmental Protection Agency (EPA)
- Does not allow "grandfathering" existing contracts
- Regulation of Specialty Coatings (table 1)

Los Angeles Area, South Coast AQMD

- Two-component coatings (e.g., epoxy), 340 g/l
- Alkyd and vinyl coatings, 420 g/l
- Baked coatings, 275 g/l
- Loss of exemption on hull paints and antifouling paints
- Allows "grandfathering" existing contracts
- Regulation of Specialty Coatings (table 1)

San Diego Area, APCD

- Air-dried coatings, 340 g/l
- Baked coatings, 275 g/l

Table 1. Specialty coatings.

Coatings	Bay Area Grams/Liter			South Coast Grams/Liter	
	9/1/89	9/1/91	9/1/94	9/1/89	9/1/91
Antifoulant	440	400 (9/1/92)	—	440	340 (9/1/92)
Heat-Resistant					
Air-Dried	520	420	420	520	420
Baked	445	360	360	445	360
High Gloss					
Air-Dried	420	340	340	490	340
Baked	—	360	275	360	275
High Temperature	650	500	500	650	500
Inorganic Zinc	650	650	340	650	650
Navigational Aids					
Painting on Shore	550	550	550	550	3[illegible]0
Painting Offshore	550	550	550	550	550
Pretreatment Wash Primer	780	780	420	780	780
Undersea Weapons System					
Air-Dried	550	340	340	420	340
Baked	460	275	275	360	275
Repair and Maintenance Thermoplastics (e.g., vinyls)	650	550	340	—	—
Special Inner Coatings	420	340	340	—	—
Military Exterior Topcoat	420	340	340	—	—
Low-Activation Interior Coatings	490	420	420	—	—
Extreme High Gloss					
Air-Dried	490	490	490	—	—
Baked	420	420	420	—	—
Sealant Coat for Wire-Spray Aluminum	610	610	610	610	610
Special Marking	490	490	490	—	—
Tack Coat	610	610	610	—	—
Elastomeric Adhesive with 15 pecent by weight natural or synthetic rubber	—	—	—	730	730

As shown in table 1, the regulations for specialty coatings are quite similar between the two major districts. Even for specialty coatings in the majority of the cases, the 1994 limits will be 340 g/l. As a result, the Navy has established 340 g/l as its target to be achieved in accordance with the timetable established by the California districts. Both regulations will allow time to reformulate to meet the future limits, provided funding is available. The diversity of regional regulations will most likely force the acceptance of the toughest regulation to achieve uniformity in paints.

NAVY'S MILITARY EXTERIOR TOPSIDE COATINGS, SAN DIEGO APCD RULE 67.18

The Navy requires all topside exterior paints to be formulated to meet the harsh demands of a salt-water marine environment. Critical to Navy operational requirements are color; gloss (match and retention); compatibility and maintainability; visual camouflage; and chemical, biological, and radiological washdown requirements. The chemical, biological, and radiological (CBR) washdown system involves dispersing salt water over topside surfaces to wash off CBR chemicals after a CBR attack.

The following coatings are topside exterior topcoat paints applied to U.S. Navy and U.S. Coast Guard ships:

TT-E-490, Enamel, Silicone Alkyd Exterior Topcoat (Black)
DOD-E-24635, Enamel, Silicone Alkyd Exterior Topcoat (Gray)
MIL-P-24441, Epoxy Polyamide Exterior Topcoat
DOD-E-699, Enamel, Alkyd Exterior Deck Topcoat (Gray)
DOD-E-698, Enamel, Alkyd Exterior Deck Topcoat (Black)
DOD-E-1115, Enamel, Alkyd Equipment Topcoat (White)
DOD-P-15146, Enamel, Exterior Topcoat (Flat Black)
DOD-P-24380, Anchor Chain Topcoat
MIL-P-24667, Topside Deck Nonskid
MIL-D-23003, Epoxy, Deck Covering Compound, Nonslip, Rollable
MIL-D-24483, Epoxy, Deck Covering Compound, Nonslip, Spray
TT-P-28, Aluminum Heat-Resistant Paint

CONSEQUENCES OF NONCOMPLIANCE TO REGULATIONS

Regulations are enforced by local area-quality management districts. This enforcement is in turn monitored by the EPA. Complying with regulations requires more than a stated intention to do so. The owner or specifier of a painting operation is responsible for knowing the regulations; developing the materials, techniques, and procedures for meeting the regulations; and disseminating those procedures to the local activities that must deal with the regulatory agencies.

The following is an example of the consequences of not complying with VOC regulations in the San Francisco area:

1. First violation: issue warning or abatement order; allow 30 days to respond.
2. Second violation: charge with misdemeanor offense; fine $1000 per day per violation.
3. Repeated violations: charge with civil offense; fine $25,000 per day.
4. Ultimate actions: stop work; jail responsible officials.

These penalties apply to both the specifier (e.g., the Navy) and the user (e.g., Navy or private shipyard). In 1987, the BAAQMD cited several Navy installations in San Francisco for violating the Miscellaneous Metal Parts Regulation. It issued a first conditional order for abatement and required each installation to come up with compliant coatings by December 31, 1988, or stop work. The Navy negotiated a resolution to this abatement order.

A private shipyard in Southern California was cited for not complying with the Miscellaneous Metal Parts Regulation. An application line that applied a solvent-based, preconstruction inorganic zinc primer was forced to shut down. The shipyard has subsequently attempted to switch to a water-based, inorganic zinc primer to meet the requirement of 340 g/l. The yard also had to install a drier to the line at substantial cost.

Several small job shops in California were forced to shut down because they used noncompliant coatings. In order to operate, these Navy contractors were authorized to use alternative compliant coatings that required massive contract changes. Several Navy installations also received fines.

Although the preceding incidents were based on the Miscellaneous Metal Parts Regulation that has been in effect for several years, similar consequences are expected for violations of the newly enacted Marine Coating Regulations (i.e., fines, stop work, jail).

These fines and work stoppages are major embarrassments to the Navy and can delay construction and overhaul of ships in both Navy and private shipyards. This, in turn, can potentially decrease the Navy's operational readiness.

DETERMINING ACTION NEEDED

It behooves the Navy to establish procedures and policies to avoid fines and work stoppages, while at the same time ensuring that compliant coatings used as replacements can meet the performance requirements of the Fleet.

A necessary step for accomplishing this is to examine current Navy practices and materials to determine the extent of noncompliance. The Navy procures virtually all of its paint by government specifications; these specifications often require a minimum of 5 to 7 years to prepare, evaluate, and implement. Therefore, regulations must be anticipated by at least 5 years. The Navy's current 5-year projections are based on a target of 340 g/l for standard (nonspecialty) coatings in accordance with the 1994 limits imposed by the major air-quality management districts in California. Under these regulations, all paints used in shipyards will be classified under the Marine Coatings rules.

Presently, the Navy's coatings consist mainly of the following three types: alkyd coatings, epoxy coatings, and copper-based antifouling coatings (table 2).

Table 2. Present Navy coatings.

Coating	VOC Contents (g/l)	Target
Alkyd Coatings Ship's interior and exterior freeboard topcoat	380–780	340
Epoxy Coatings Exterior and interior immersion areas, interior wet spaces, and exterior freeboard primers	200–410	340
Copper-based Antifouling Coatings	263–440	400*

*340 g/l may be required by SCAQMD.

The conclusions drawn from these data are that alkyd coatings are the main problem for both the exterior and interior of ships, and that replacement coatings would be required. For epoxy coatings, the technology is available for coatings to meet the VOC requirements, although some specifications would require modifications. The copper-based, antifouling coatings are also readily available in VOC-compliant versions. Preliminary figures based on approximate volumes of these materials are that many of the Navy's coatings comply with the proposed San Francisco Bay Area, South Coast Marine Coatings regulations, and the San Diego APCD.

STRATEGY FOR COMPLIANCE

Several alternatives are available for meeting restrictions on VOCs, including

- Variances (i.e., exemptions or exceptions)
- Use of solvent recovery equipment
- VOC-compliant coatings

Variance

Variances are considered a short-term, temporary solution. Ultimately, the Navy, along with other industry users, will be required to use low-VOC coatings. The Navy has argued effectively for certain exemptions or delays in VOCs for special-use coatings.

Solvent Recovery Equipment

The option of solvent recovery requires installing extensive add-on equipment (i.e., hydrocarbon absorption filters, and catalytic or thermal incinerators) that reclaims or destroys the solvents. This equipment is expensive and difficult to install on ships.

VOC-Compliant Coatings

The option of reformulating or developing coatings to meet VOC regulations is considered the most feasible, long-term solution. Among the types of coatings that can meet low-VOC requirements are high-solids coatings, water-based coatings, powder coatings, and thermal spray (metallic) coatings. The Navy currently has active programs to develop and utilize aluminum wire-spray coatings and powder coatings for specialized components and parts of ships.

Accordingly, a program was established to develop VOC-compliant coatings for Navy requirements. The initial focus is on epoxy and alkyd coatings to meet a target level of 340 g/l.

Advantages of New Formulations. The anticipated advantages of the new formulations (table 3) are that they

- meet VOC requirements.
- reduce VOC emissions.
- reduce toxic substances (e.g., lead chromate, asbestos).
- improve worker safety and health (i.e., less exposure to solvents and toxic materials).

Table 3. NAVSEA 05M1 cognizant specifications: VOC-compliant status.

Compliant Specifications	DOD-P-24648	Primer, alkyl silicate
	DOD-C-24596	Nonflaming, fire-protective coatings
	DOD-P-21035	Zinc dust paint
	MIL-C-46081	Thermal insulating coating
	DOD-P-15144	Binder for antisweat coatings, Formula 34
	DOD-P-24631	Paint, camouflage for submarine
	MIL-P-24441	Paint, epoxy polyamide
	DOD-P-24236	Epoxy, tank lining
	DOD-C-24654	Epoxy, potable water tanks
	MIL-P-15931	Paint, vinyl antifouling
	DOD-E-24647	Paint, antifouling, ship hull
	DOD-P-24655	Paint, underwater hull, corrosion
	DOD-C-24667	Nonskid, slip-resistant coating
	MIL-P-15173	Pigment, magnesium silicate
	MIL-W-15234	Whiting
	MIL-S-15191	Silica, diatomaceous
	DOD-V-15218	Varnish, mixing, phenolic
	MIL-C-19565	Coating compound, thermal insulation
	DOD-R-21417	Resin, chlorinated alkyd solution
	DOD-C-22325	Tinting color for interior nonflaming paints
	MIL-P-15145	Enamel, zinc dust tank coating, Formula 102
Noncompliant Specifications	TT-P-645	Primer, zinc chromate, Formula 84
	MIL-P-24351	Primer, Formula 6N35
	DOD-E-1115	Enamel, interior white, Formula 30
	MIL-E-15090	Equipment enamel, light gray, Formula 111
	DOD-E-24607	Chlorinated alkyd nonflaming interior enamel
	DOD-P-15146	Paint, exterior dull black, Formula 104
	DOD-E-24635	Enamel, silicone alkyd
	DOD-E-18214	Enamel, interior deck, Formula 19
	DOD-E-699	Enamel, exterior deck, Formula 20
	DOD-E-700	Enamel, interior deck, Formula 20L
	DOD-E-698	Enamel, deck alkyd, Formula 24
	DOD-E-18210	Enamel, deck alkyd, Formula 23
Specifications to be Cancelled	DOD-P-15238	Vinyl, pretreatment wash primer, Formula 117
	MIL-P-15930	Primer, vinyl-zinc chromate, Formula 120
	DOD-E-1265	Enamel, exterior alkyd, Formula 5-0 NAVSEA Formula 21
	MIL-E-20090	Enamel, alkyd stripping, Formula 41
	TT-S-711	Interior wood stain
	DOD-P-15183	Paint, exterior alkyd, Formula 109
	MIL-P-24380	Paint, anchor chain, chlorinated rubber
	MIL-R-15189	Resin, phenolic
	MIL-E-5556	Enamel, camouflage
	MIL-P-22298	Paint, antifouling polyisobutylene, Formula 133
	MIL-P-22299	Paint, antifouling polyisobutylene, Formula 134
	TT-L-1155	Linseed oil, alkyd refined

Reformulation Activities. The following are descriptions of Navy (corrosion-control branch) coating reformulation activities.

Epoxy Polyamide (MIL-P-24441). Because this is such a high-volume and vital paint for the Navy, reformulation was aimed at both short-term and long-term needs. A short-term solution is to revise the existing MIL-P-24441 specification to increase the solids of existing formulations and to specify a maximum VOC content of 340 g/l.

The Navy long-term reformulation goal is to reduce the VOC content of the existing specification and to remove hazardous ingredients. Performance tests were selected from the current version of MIL-P-24441 specifications DOD-P-23236 and DOD-C-24654. The laboratory tests were completed.

Shipboard applications are planned; their proposed milestones are shown in table 4.

Table 4. Milestones for developing VOC-compliant epoxy polyamide.

Fiscal Year	Milestones
1989-1990	Full-scale ship applications Laboratory qualification of manufacturers Finalize specification requirements
1990-1991	Continue ship application Continue qualification Evaluate ship performance (ship inspections) Publish specification In-service-engineering consultant effort
1991-1992	Continue ship applications Continue qualification Evaluate ship performance (ship inspections) In-service-engineering consultant effort

Lead and Chromate-Free Oil Alkyd Primer (TT-P-645). The formulation goal is to eliminate the zinc chromate and to lower the VOC to 340 g/l.

Silicone-Alkyd Topcoat (TT-E-490). A new, low-VOC, solvent-based, silicone alkyd has been reformulated to replace TT-E-490 and the analogous specification DOD-E-24635. Further screening tests and shipboard application by the Navy are planned in 1990 and 1991. In addition, the General Services Administration (GSA) has prepared a high-solids version of TT-E-490 with a VOC content of 420 g/l for use as an architectural coating.

Equipment Enamel (MIL-E-15090). The Navy has developed a specification based entirely on performance tests; there are no requirements for a generic type of coating or materials, other than a VOC limit of 295 g/l.

Deck Enamel. The Navy is planning to combine the following five specifications that cover interior and exterior deck enamels into one single specification, with a VOC of 340 g/l or less: DOD-E-698, DOD-E-699, DOD-E-700, DOD-E-18210, and DOD-E-18214 (see table 3).

Alkyd Gloss Enamel (TT-E-489). TT-E-489 is another specification widely used by the Navy for exterior topcoats. The U.S. Army (Fort Belvoir R&D Center) has recently issued a new version of this specification with a VOC content of 420 g/l, maximum. At that level, the coating will be suitable for architectural or other applications, but will need further reformation to meet the marine VOC limits.

Additional Reformulation Targets. In addition to the reformulations just covered, the Navy plans to develop VOC-compliant versions of TT-P-28, "Heat-Resisting Aluminum Paint," that is also maintained by the Army; and MIL-P-24351, DOD-E-24607, DOD-P-15146, and DOD-E-1115 (table 3).

Logistics Support. In addition to the efforts in reformulation, and laboratory and service evaluation, the Navy must also provide additional logistics support in the program to implement low-VOC coatings. These may include new equipment and facilities, personnel training, additional record keeping, additional consultation, and troubleshooting.

A Navy activity often must procure a VOC-compliant coating before a specification has been formally issued. The Navy has made the following information available to Naval facilities in noncompliant air-pollution areas: preliminary copies of new specifications such as TT-P-645 (zinc molybdate alkyd primer) and MIL-E-15090 (light-gray equipment enamel).

VOC METHOD

One issue that has not been resolved that could significantly affect the acceptability of the low-VOC specifications is the method for determining the VOC content. Most of the Navy specifications will be referencing ASTM D-2369 as the method for determining VOC. The most recent version of this specification recognizes that the temperature at which the paint is heated can affect the VOC level; therefore, it allows for deviation from the stated temperature of 110°C (230°F). Formulators, manufacturers, and users have claimed that heating marine and architectural paints to 110°C (230°F) causes paint decomposition and higher loss of volatiles than at the natural surface temperature; thus, the measured VOC is higher than anticipated and may not meet the required limit.

3.0 SUMMARY

Recognizing the problems caused by VOC emissions from coatings for ships, the U.S. Navy is committed to reducing the levels of VOC content. These levels are established by the San Francisco Bay Area and South Coast Air-Quality Management districts and the San Diego APCD. Note that the Navy-related VOC emissions in these three districts are relatively low when compared with other industrial sources.

The general target for VOC content is 340 g/l and is to be achieved by 1991 or 1992. The primary approach for achieving compliance is to reformulate existing alkyds and epoxies, using high-solid coatings, water-based coatings, and powder coatings. This reformulation is being undertaken by both Navy and private-sector laboratories.

The goal of the reformulation is to develop paints with performance and application properties equivalent to those currently being used. The reformulation program includes laboratory tests as well as service tests on various Navy vessels in all parts of the United States.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1990	Final: Oct 1990 – Nov 1990

4. TITLE AND SUBTITLE

NAVY COMPLIANCE WITH VOLATILE ORGANIC COMPOUNDS (VOC) REGULATIONS FOR MARINE COATINGS

5. FUNDING NUMBERS

In-house funds

6. AUTHOR(S)

T. Thielen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Ocean Systems Center
San Diego, CA 92152-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

NOSC TD 2035

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Air-pollution regulations in California are requiring the U.S. Navy and the private sector to develop new types of coating specifications and paints to meet California Air-Pollution regulations and volatile organic compounds (VOC) requirements. The progress made in these areas and the impact of these regulations upon Navy operations are discussed.

14. SUBJECT TERMS

volatile organic compounds
VOC-complying coatings
VOC emissions

15. NUMBER OF PAGES

14

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAME AS REPORT

INITIAL DISTRIBUTION

CODE 0012		(1)
CODE 0065	T. Thielen	(10)
CODE 0144	R. November	(1)
CODE 921	J. Puleo	(1)
CODE 961	Archive/Stock	(6)
CODE 964	Library	(3)

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